

**CLAIMS**

What is claimed is:

- 1 1. (currently amended) A method of determining a parameter of interest for a region of an  
2 earth formation using a nuclear magnetic resonance (NMR) instrument conveyed  
3 in a borehole, the method comprising:
  - 4 (a) producing a static magnetic field in a region including said region of  
5 interest;
  - 6 (b) transmitting a sequence of radio frequency (RF) pulses ~~for~~ and producing  
7 an RF magnetic field in said region, said RF magnetic field having a  
8 spatially varying intensity in said region ~~and a direction substantially~~  
9 ~~orthogonal to a direction of said static magnetic field, a subset at least one~~  
10 ~~of said RF pulses further~~ having a pulse length related to zeros a zero of a  
11 Bessel function;
  - 12 (c) receiving NMR signals ~~having amplitudes~~ produced by said RF magnetic  
13 field; and
  - 14 (d) determining said parameter of interest using said ~~amplitudes received~~  
15 NMR signals.
- 16
- 1 2. (currently amended) The method of claim 1 wherein said said parameter of interest  
2 comprises at least one of (i) a spin density function, (ii) porosity, (iii) fluid  
3 content, (iv) permeability, (v) longitudinal relaxation time, and, (vi) transverse

10/717,123

4 relaxation time.

5

1 3. (currently amended) The method of claim 1 wherein said NMR signals comprise free  
2 induction decay signals ~~associated with said subset of RF pulses.~~

3

1 4. (currently amended) The method of claim 1 wherein said subset of sequence of RF  
2 pulses comprises tipping pulses, ~~the pulse sequence further comprising a plurality~~  
3 ~~of and refocusing pulses associated with said tipping pulses,~~ and wherein said  
4 NMR signals comprise spin echo signals.

5

1 5. (currently amended) The method of claim 3 wherein determining said parameter of  
2 interest further comprises performing an inverse Hankel transform on said NMR  
3 signals.

4

1 6. (currently amended) The method of claim 5 wherein determining said parameter of  
2 interest further comprises using a spatial mapping to map ~~said a~~ spin density to a  
3 spatial location.

4

1 7. (currently amended) The method of claim 4 wherein said sequences sequence of RF  
2 pulses ~~are is~~ of the form:

3  $[\tau_j - \frac{TE}{2} - (R - TE)_j, -TW]_j$

10/717,123

4 where TE is a time interval between refocusing pulses R,  $\tau_j$  is a tipping pulse, TW  
5 is a wait time,  $i$  is the index of the number of refocusing pulses, and  $j$  is the index  
6 of the number of CPMG (or modified CPMG) sequence acquired for a single  
7 tipping pulse.

8

1 8. (original) The method of claim 7 wherein determining said parameter of interest further  
2 comprises summing the spin echo signals resulting from said sequence of RF  
3 pulses over the index  $j$  for a selected value of  $i$ .

4

1 9. (original) The method of claim 8 wherein said summing is a weighted summing.

2

1 10. (currently amended) The method of claim 9 wherein determining said parameter of  
2 interest further comprises using a spatial mapping to map said a spin density to a  
3 spatial location.

4

1 11. (currently amended) The method of claim 6 further comprising determining spins  
2 associated with a portion of the region ~~of interest~~ outside said borehole.

3

1 12. (original) The method of claim 10 further comprising determining spins associated  
2 with a portion of the region outside said borehole.

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10/717,123

1 13. (currently amended)The method of claim 6 further comprising partitioning said spins  
2 into azimuthal sectors.

3

1 14. (currently amended)The method of claim 10 further comprising partitioning said spins  
2 into azimuthal sectors.

3

1 15. (original)The method of claim 1 further comprising repeating (a) – (d) for a number of  
2 different azimuthal orientations of said instrument.

3

1 16. (currently amended)The method of claim 15 further conveying said NMR instrument  
2 into said borehole on a bottom hole assembly.

3

1 17. (currently amended)An apparatus for determining a parameter of interest ~~for of~~ a  
2 region of an earth formation comprising:

3 (a) a magnet ~~for~~ producing a static magnetic field ~~having a direction within~~  
4 the region;

5 (b) a transmitter ~~for~~ transmitting a sequence of radio frequency (RF) pulses ~~for~~  
6 and generating a RF magnetic field in said region, said RF magnetic field  
7 having a spatially-varying intensity in said region ~~and a direction~~  
8 ~~substantially orthogonal to the direction of the static magnetic field,~~  
9 (c) a processor ~~for~~ controlling said transmitter and defining a subset ~~at least~~

10/717,123

10                   one of said RF pulses to have a pulse lengths length related to zeros a zero  
11                   of a Bessel function;

12                   (d) a receiver for receiving NMR signals produced by said RF magnetic field;  
13                   and

14                   (e) a processor for determining said parameter of interest from amplitudes of  
15                   said NMR signals.

16

1       18. (currently amended) The apparatus of claim 17 wherein said said parameter of interest  
2                   comprises at least one of (i) a spin density function, (ii) porosity, (iii) fluid  
3                   content, (iv) permeability, (v) longitudinal relaxation time, and, (vi) transverse  
4                   relaxation time.

5

1       19. (currently amended) The apparatus of claim 17 wherein said NMR signals comprise  
2                   free induction decay signals associated with ~~said subset of RF pulses~~.

3

1       20. (currently amended) The apparatus of claim 17 wherein sequence of pulses of said  
2                   subset of RF pulses are comprise tipping pulses, the pulse sequence further  
3                   comprising a plurality of and refocusing pulses associated said tipping pulses and  
4                   wherein said NMR signals comprise spin echo signals.

5

1       21. (original) The apparatus of claim 17 wherein said processor in (e) is configured so as

10/717,123

2 to determine a spin density as a function of said RF field intensity.

3

1 22. (original) The apparatus of claim 21 wherein said processor is configured to transform  
2 said spin density to a spatial location.

3

1 23. (currently amended) The apparatus of claim 21 wherein said sequences sequence of  
2 RF pulses are is of the form:

3  $[\tau_j - \frac{TE}{2} - (R - TE)_i - TW]_j$

4 where TE is a time interval between refocusing pulses R,  $\tau_j$  is a tipping pulse, TW  
5 is a wait time,  $i$  is the index of the number of refocusing pulses and  $j$  is the index  
6 of the number of CPMG (or modified CPMG) sequence acquired for a single  
7 tipping pulse.

8

1 24. (currently amended) The apparatus of claim 17 wherein the same antenna is used  
2 for transmitting said RF pulses and receiving said NMR signals.

3

1 25. (original) The apparatus of claim 17 wherein said processor in (c) and said processor  
2 in (e) are the same.

3

1 26. (new) The method of claim 1 wherein said Bessel function is a Bessel function of  
2 zero order and first kind.

10/717,123

3

1 27. (new) The apparatus of claim 17 wherein said Bessel function is a Bessel function of  
2 zero order and first kind.

3

1 28. (new) A method of composing a radio frequency (RF) pulse sequence for use in a

2 nuclear magnetic resonance (NMR) apparatus, the method comprising:

3 (a) defining a length of at least one pulse of the RF pulse sequence based on a  
4 zero of a Bessel function;

5 (b) producing a RF field with said RF pulse sequence; and

6 (c) analyzing NMR signals resulting from the produced RF field.

7

1 29. (new) The method of claim 28 wherein said Bessel function is a zero order Bessel  
2 function of the first kind.

3

1 30. (new) A nuclear magnetic resonance (NMR) apparatus comprising:

2 (a) a processor that:

3 (i) defines a length of at least one pulse of a radio frequency  
4 RF pulse sequence based on a zero of a Bessel function, and

5 (ii) pulses a transmitter with the RF pulse sequence,  
6 wherein the transmitter produces a RF field;

7 (b) a receiver which receives NMR signals resulting from the RF field;

10/717,123

8 (c) a processor which analyzes the received NMR signals.

9

1 31. (new) The NMR apparatus of claim 30 wherein the Bessel function is a Bessel  
2 function of zero order and the first kind.

10/717,123

9